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Nuisance Alarms in Aircraft Cargo Areas and Critical Telecommunications Systems: Proceedings of The Third NIST Fire Detector Workshop

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FIRE DETECTION FOR CRITICAL TELECOMMUNICATIONS EQUIPMENT

A telecommunications industry perspective of fire detection was given by Ron Marts of Bellcore. Miles Hanley of Bell Atlantic presented his company's fire detection strategy and its relation to the reduction of false alarms. Jeffrey Betz described the fire safety practices of AT&T. John Parssinen of Underwriters Laboratories presented an overview of different fire detectors and described UL's role in certifying detection systems for industrial applications. The discussion sessions were led by Richard Bukowski and Emil Braun, both of NIST. This section of the report is a compilation of their comments and the discussions that ensued.

Background

A fire in a critical telecommunications facility poses a number of unique problems that the earliest possible detection could help alleviate. First, the lost service associated with the down time from a fire is normally much more significant than the loss due to property damage. Because of this, taking equipment off line to remove the electrical power is to be avoided if possible, but if necessary it must be accomplished in an orderly fashion by trained employees, which may be inconsistent with the needs or desires of the fire fighters. In many situations, removal of power is sufficient to extinguish the fire since much of the material used in telephone equipment does not readily support a flame. Conversely, for high electrical current devices, the fire may never be fully extinguished even by applying a suppressant unless the power is removed (or the fuel is totally consumed). Water can create a personnel hazard when applied to electrically powered equipment and short out adjacent devices. Halons generally pose no problem if they come in contact with electrical equipment, but alternatives such as fluorocarbons and hydrofluorocarbons tend to form larger concentrations of acid gases when applied to a fire, increasing the possibility of collateral damage caused by the deposition of acidic soot on remotely located equipment.

Thus, early detection of a fire threat is paramount to the telecommunications industry to permit the widest choice of responses to minimize possible losses. However, if not done intelligently, the rush to earlier detection could lead to an increase in nuisance alarms to unacceptable levels.

Ron Marts: The following statistics were cited to put the size of the regional Bell operating companies (RBOCs) into perspective: there are 140 000 000 access lines, 13 000 switches in 7500 cities and towns being served, 10 400 central offices, and 14 000 000 m^2 (150 000 000 ft^2, or equivalent to 150 large shopping malls) of floor space in need of fire protection. The RBOCs have an embedded base of about 1 000 000 smoke detectors, 10 000 control panels, and are served by 8500 fire departments. In the last 25 years, there have been only six major fire incidents, with no deaths due to fire in the 120 year history of the Bell system. Nuisance alarms occur, but have not been epidemic.

The nature of the spaces to be protected has changed with advances in communications technologies. In the "old days", switches were analog, 3.36 m (11 ft) high placed in rows with tight aisles in rooms with 4.9 m (16 ft) ceilings. The ventilating system had slow moving air and the cable materials were combustible, leading to hot flaming fires when they did occur. Many people were available in or adjacent to the critical switching rooms to detect a fire. These switches contained relatively unsophisticated redundancies but were not highly susceptible to airborne contamination. Early strategies for fire protection were driven by AT&T/Western Electric's desire for uniformity, i.e., the one-size-fits-all approach. Facilities were equipped with standpipes and hoses, and hand-held fire extinguishers contained CO_2 or water as dictated by code. Smoke detection was through high voltage ionization sensors, with one detector in each 6.1 m by 6.1 m (20 ft by 20 ft) building bay. The fire signal was handled as a trouble alarm, and the employees were trained in how to react to the alarm.

In today's world, the switches are digital with many sophisticated redundancies. The frame heights have been reduced to 2.1 m (7 ft), but the ceiling heights remain unchanged. The more compact nature of the digital switches leads to their placement in clusters with tight aisles and frequently in large open spaces. The combustible cable materials have been replaced with much more flame resistant wiring, and the HVAC systems use fast moving air. An ignition event in this type of architecture might result in a smoldering fire with a low rate of heat release and stratifying smoke layer. Few people are present, and the equipment is highly susceptible to airborne contamination. While the central office (CO) is still the major hub of land line service, the divergence of network requirements has created the need for satellite facilities such as remote huts, repeaters, underground controlled environmental vaults (CEV) and on-premises switching (installing telephone switches on customers' premises, as opposed to the telephone company's buildings). The boom in cellular telephone use has created the need for tens of thousands of cell sites (the location of the antennas) where the signals are relayed to ground-based mini COs. The surge of competition in the industry has created hundreds of competitive local exchange carriers (CLEC) who are allowed to install their equipment in incumbent local exchange carrier's (ILEC) facilities.

Current fire protection strategies are driven by many forces, including code requirements, Bellcore and intra-company practices, available technologies, and risk management and business needs. Standpipes still exist in all COs, but many companies have chosen to remove hose cabinets. Fire extinguishers are installed according to building codes, NFPA 10, and Bellcore recommendations. Companies are shifting to very early warning detection systems, either low voltage photoelectric spot detection or aspirating systems, or a combination of both.. These systems offer higher levels of intelligence and can be supervised remotely. Fire alarms are routed to the company's switching control center (SCC), building operations control center (BOCC), and to the local fire department. It is the fire department, not the employee, that is trained to respond to a full alarm. Many companies have fire fighter training programs, so that the local fire departments can familiarize themselves with the CO.

Bellcore's position is that there is no such thing as a "false" alarm since every alarm tells you something. A wanted alarm can be thought of as a "good" alarm bringing bad news, and conversely, an unwanted alarm is a "bad" alarm bringing good news. The unwanted alarm could signify a non-fire problem with the detection system or its environment, which should be corrected, or it could be a response to a non-threatening physical source and construed as a nuisance. (The fire department views nuisance alarms as false alarms.) Nuisance alarms can be put into five categories:

- contractors' work, such as welding or other hot processing, physically damaging the equipment, or improperly disconnecting equipment;
- maintenance, or lack thereof;
- supervisory problems with equipment;
- contamination of the air or the interior of the detection system by smoke, dust, humidity or paint fumes; and
- lightning.

In summary, Marts stressed that modern telecommunications equipment is compact, and frequently in large open areas with a high level of cooling through fast moving air. The telephone switches present a low fuel load categorized as a class C light hazard, producing a slow burning smoldering fire but with a high susceptibility to contamination from smoke. Highly maintained, very early warning, intelligent detection is used with multiple levels of alarm. Fast response and entry by a properly trained fire department is the main defense, as opposed to fixed, automatic suppression systems. The history of nuisance alarms varies among companies, but none report them as being epidemic, typically less than one a day for an individual company. Bellcore continues to explore new technologies in fire protection for its clients and to create uniform and consistent recommendations for them. Bellcore is a vendor-neutral fire protection consultant and participates heavily in the code change activities of the model codes and the IBC, in various fire protection symposia, and serves as an active member of the new NFPA Telecommunications Committee.

Miles Hanley: The fire detection strategy for Bell Atlantic and its relation to the reduction of false alarms was presented. The systems which were in place prior to the new strategy were high voltage and hard wired, consisting mainly of ionization-style heads. They also had installed early versions of low voltage non-addressable heads. A decision to upgrade was made based upon the findings of the Network Reliability Counsel, the desire for incipient (low energy) fire detection, the age and high maintenance costs of the previously installed systems, and the desire to reduce the number of false alarms.

The major causes of false/nuisance alarms at Bell Atlantic were given as the following: dirty heads, soldering in the main frame area, cigarette smoking, high airflow, construction dust, and incorrect detector application. Statistics were cited which indicated that replacing the existing systems with an addressable system would cut in half the dollars spent on alarm call outs; and by going to air sampling with addressable heads, Bell Atlantic could reduce costs by another factor of two. A system-wide upgrade was projected to save the company about $125 000 a year due to the reduced number of nuisance alarms.

Non-equipment areas are now protected with addressable, analog spot detectors. This includes hallways, lunch/break rooms, and rest areas. The central office switches, including toll rooms, main frames, and power rooms, rely upon air sampling using a piped network with laser detection. These systems have an adjustable sensitivity level, a time delay, built-in air filter cartridges, and an ability to set the alarm threshold above the prevalent ambient condition. In addition, they are equipped with drift compensation, a maintenance alert, addressable detectors and sensitivity adjustment, alarm verification and pre-alarm capability, with alarm decision algorithms programmed into the software.

Jeffrey Betz: The activities of the engineering environment, health and safety processes at AT&T were explained as they applied to fire detection and safety. ANSI, ASTM, and NFPA (70 and 72) standards provide guidance in the design, installation, operation, testing and maintenance of buildings, systems, processes and equipment. AT&T Practices and AT&T Letters present the company's prescribed level of acceptability or approved model used as a basis of comparison to the standards. Fire prevention minimizes the likelihood of fire, but if it occurs, fire spread is restricted by the strict enforcement of standards/practices/codes, by limiting the potential for ignition sources to be consistent with designed occupancy, by good housekeeping and storage practices, and by proper management of access and egress. Fire control based upon enforced standards/practices/codes minimizes a fire incident or smoke condition spreading beyond the area of origin by careful planning of the site and space layout, by compartmentalization, by smoke management, by proper selection of structural and fire protection materials, and by assured fire service access.

Fire detection is designed to detect a fire condition as early as possible, so that actions can be taken to prevent smoke generation and open flames, to evacuate occupants, and to minimize damage to property and the network. Activation of the fire alarm system is through any of the following actions: manual pull station; positive response of an individual detector; or by a fixed system. All standard designs of fire detectors (smoke, heat, and flame) are encountered in AT&T facilities, including sprinkler heads. Air sampling smoke detection systems (ASSDS) are used specifically to protect priority equipment spaces, but early warning detection is the general philosophy for all telecommunication facilities. Figure 1 shows a sectional and plan view of a typical system. In it, air is continuously drawn from a protected area through a network of piping with sampling holes at specified intervals.

AT&T Engineering and Operation Practices documents require that the selection of a smoke detection system be based upon the type of fire most likely to occur in the space being considered, the potential for damage from a fire in the area, the potential for smoke damage, and the types of materials that may burn in a fire. Changes in the use of a room or space (i.e., from offices to equipment) will change the type of detection required because the materials present will change. All leased or owned buildings, structures, huts, and CEVs containing network communications equipment shall be provided throughout every area/room with an automatic detection system. This requirement applies to all AT&T areas with three-dimensional conveyances (3DC) and condo agreement buildings. Photoelectric type spot detectors are appropriate for use in non-priority areas such as storerooms, janitor closets, toilet rooms, cafeterias and break rooms, administrative offices, hallways, and mechanical equipment rooms. Ionization detectors are specifically precluded from use in these areas.

Multi-sensor type spot detectors integrate into one unit a photoelectric, ionization, and/or heat sensor. The sensor outputs are linked through an integral microprocessor which interprets the combined signals through an intelligent algorithm to produce a signal that is more sensitive to a variety of fires. Ultraviolet flame detectors are used in the presence of combustible liquids, while UV/IR combination sensors are designed to reduce the tendency of a flame detector to false alarm in the presence of arc welding, lightning and sunlight. Heat detectors are acceptable for telecommunication facilities that are not compatible with the use of smoke or flame detection. All heat detectors are of the

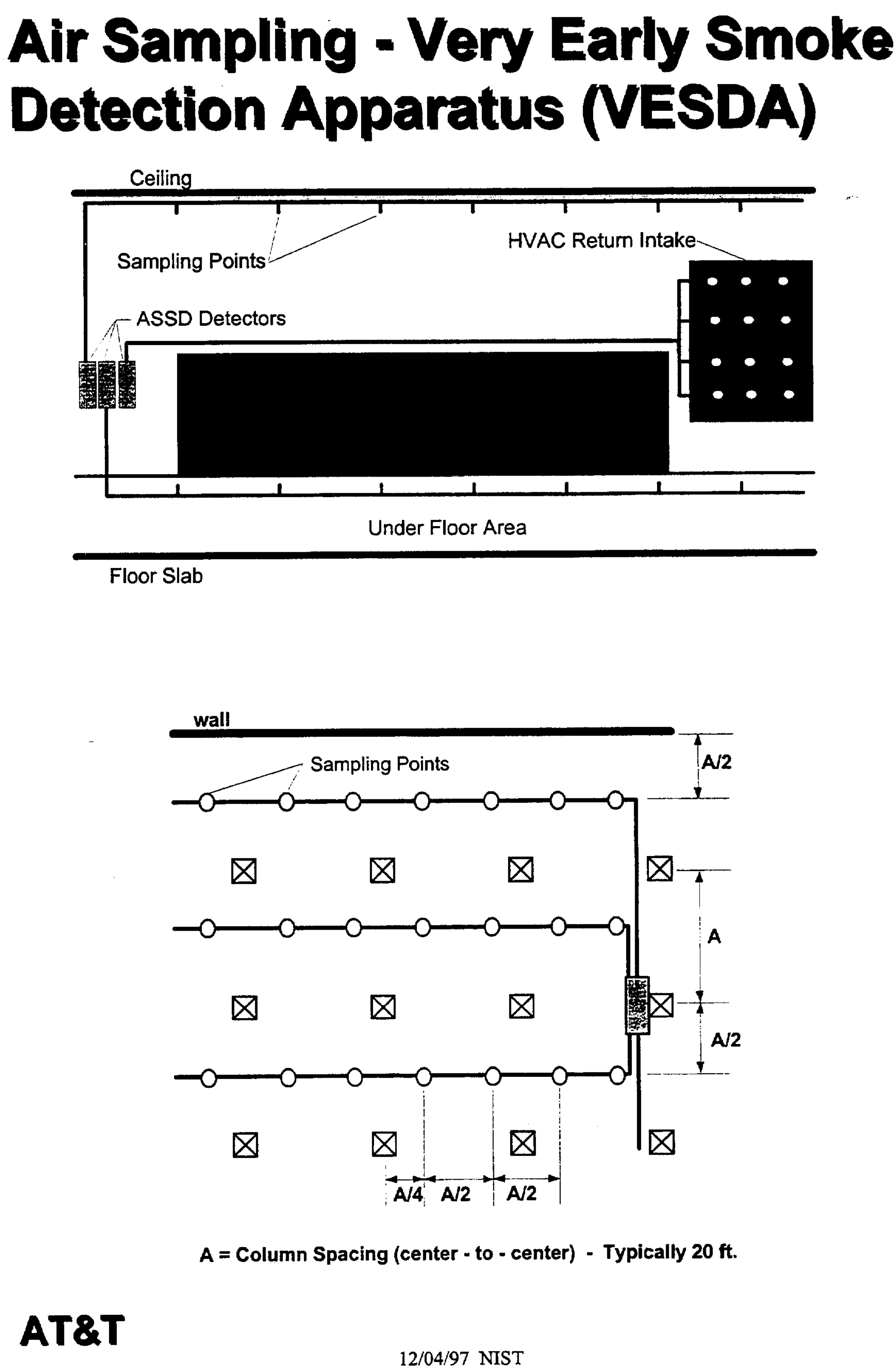

Figure 1. Layout of a very early smoke detection system for a telecommunications facility.

rate-compensated, fixed-temperature type, and are individually addressable through an interface panel. Spaces which are commonly protected with heat detectors are generator rooms, penthouses, garages/loading docks, and separated unheated storage. Fusible-link heat detector/sprinkler heads are used in non-telecommunications areas.

Photoelectric spot detectors are spaced to cover 37 m^2 (400 ft^2) each in administrative or common areas and in cable vaults. Individual air sampling ports tied to photoelectric sensors are spaced to cover 18.5 m^2 (200 ft^2) when used in cable vaults, in priority telecommunication spaces, and in data center/computer rooms.

Experience has demonstrated that when heating, ventilation and air conditioning (HVAC) systems are operating, the first detector to recognize a fire will be sampling the return intakes from affected space. If the HVAC systems are not functioning, then the ceiling/raised floor detection system will respond most quickly. Not less than two separate detector control units are required in every priority telecommunications equipment room. One detector covers the HVAC return air intake, and a second detector covers the ceiling of the room.

Fire detection systems are functionally tested (at prescribed intervals) to ensure that each and every device, appliance and operational mode is performing as designed. This includes all smoke, heat and flame detectors and associated devices or appliances, and encompasses interactions, interlocks and special features. False alarms in these systems can be attributed to intentional activation, improper installation, or improper maintenance activities. The term nuisance alarm is applied to conditions resulting from an improper installation or misapplication of a detection device, a changing environmental condition, improper maintenance activities, or "friendly" fire/smoke.

John Parssinen: Different types of fire sensors certified by Underwriters Laboratories for use in telecommunications and other commercial applications were described. The performance of smoke detectors are evaluated in reduced and full-scale chambers using standards UL 217[2] and UL 268[3]. UL 521[4] applies to heat detectors for fire protective signaling systems intended to be installed in ordinary indoor and outdoor locations. UL 539[5] applies to heat activated, mechanically or gas operated heat detectors intended for indoor installation. UL 2034[6] covers electrically operated devices designed to protect ordinary locations of family living units, including recreational vehicles and mobile homes, from excessive levels of CO produced in combustion engine exhausts, fireplaces, and abnormal operation of fuel-fired appliances. Carbon monoxide produced in an unwanted fire is not an excluded source, but fire detection is not specifically mentioned as an intended use.

Smoke detectors are listed as being either ionization or photoelectric, with the photoelectric being further categorized as point-type or projected-beam-type. Combinations of these types are becoming more common, with heat detection sometimes also employed. Air sampling can be used in combination with any of these smoke detector designs. Heat detectors can have a fixed temperature set-point as measured at a point or along a line. Rate-of-rise and rate-compensated heat detectors are designed to improve the sensitivity of the system and to reduce the possibility of alarming due to extremes of environmental temperature. Flame detectors certified by UL sense the ultraviolet, infrared, or combinations of these portions of the spectrum. New technology sensors are being developed that sense other fire signatures such as CO and CO_2, and microprocessor based systems are available that allow more flexibility in alarm determination.

Discussion

The discussion sessions were focused on answering the following questions as they apply to critical telecommunications areas: (i) What conditions produced by a nascent fire can be sensed to warn of a threatening situation? (ii) In what time-frame must a response strategy be formulated, and what are the consequences of a false-positive? (iii) What physical environments or activities are likely to lead to a false-positive? (iv) What test methods are required to evaluate the immunity of fire detection systems to false-positives? (v) What are the action-items for the group, and who should take responsibility for each?

The primary fire signatures in modern telecommunication switch rooms are produced by low energy, smoldering fires. The sources could be cabling, PVC, or plastic housings. Smoke stratifies below the ceiling and is generated in abundance. Current detection strategies involve layered protection; i.e., sampling from different heights in the room to overcome problems due to smoke layer stratification. Temperature increases are low in these types of fires, but near the reaction zone they can be hundreds of degrees above the highest measured ambient. HCl is produced by the decomposition of PVC cables, but current smoke detector technologies can match the sensitivity of HCl detectors without the disadvantages (high maintenance, non-response to fuels not containing chlorinated species). CO and CO_2 are produced from all fires of carbon-based materials and could be indicative of a growing threat, but the reliability of current gas sensing technologies have yet to be proven.

Other distinct fire scenarios could result from cabling under raised floors similar to configurations in mainframe computer rooms, or from hydrogen production in battery rooms. The materials used in these areas (e.g., battery cases, fuse housings, power cables) may differ from the switch room. Selective gas sensors might give earlier detection, but records of fires in raised floor areas and battery rooms indicate that losses are very low in these scenarios, which may suggest that these environments are sufficiently protected with existing technologies.

The amount of time available between the detection of a fire and the onset of a mitigation strategy is dictated conventionally by the maximum size (expressed in terms of heat release rate, or HRR) of fire that can be tolerated and the growth rate. Maximum tolerable sizes are generally less than 100 kW, with some deeming 25 kW to be an upper limit. Detection should occur prior to an HRR of 1 kW (0.1 kW is suggested by some for critical equipment particularly susceptible to smoke damage). For these situations, the rate of production of particulate matter may be a preferable gauge of the fire severity rather than HRR since the rate of heat generation over and above the heat dissipation of the electrical power may be minimal.

The actual time available between the onset and detection of the fire is controlled mostly by the practical response time for the given operation. For a central office with even minimal staffing, an employee can investigate an alarm signal in less than a minute, at which point the fire can be confirmed and a decision made to isolate and depower the affected piece of equipment, to activate a suppression system (few telecommunications operators utilize automatic release of agent), to power-down more extensively (considered a last resort action), and/or to notify the fire department. On the other hand, cell sites are often remote, requiring times greater than an hour for an employee or the fire department to investigate. If it is a real fire and the site is not equipped with an automatic suppression system, the equipment will be written off. The fire alarm in that situation acts as a signal to the maintenance crew to install a new facility.

Fire alarms divert people to investigate the source, cause the telecommunications company personnel to evacuate a central office, and may result in the dispatch of the fire department. If the alarm is the result of a false-positive, then as a minimum there is a dollar penalty associated with the lost productivity of the employees, plus any cost to the fire department if they respond. If the facility (such as a remote cell site) is equipped with an automatic suppression system, a false-positive can lead to the inadvertent release of agent. Automatic power shutdowns are never employed since maintaining a dial tone is paramount; hence, a false-positive will not lead to loss of service. As a rule, a certain level of nuisance alarms are accepted by the industry because they indicate that the fire detection system is operating and responding to something foreign in the environment. A serious problem occurs only when the number of nuisance alarms exceeds an (unknown) desensitization limit, and employee confidence in the system is eroded.

Nuisance alarms can be traced to a number of sources. Internal to the facilities, the primary causes are poor maintenance of the detector heads, poor housekeeping procedures, particulate formed during routine soldering operations or from a defective light ballast, and excessive moisture or dust. External to the equipment room, emissions from traffic, an idling truck, or road work can be inadvertently entrained through the ventilation system. Adjacent occupancies (e.g., employee lounges, kitchens, garages) can also contribute contaminants through leakage paths in the HVAC system.

Current test methods used by UL to certify that a smoke detector will respond to a fire appear adequate. Methods for qualifying systems in the field are not, and there is no written industry standard for this process. Most installers burn a short length of wire in the room after installation to make certain that the system will respond. This technique is thought to be viable and convenient; however, it is a highly transient event which does not represent the more serious threat of a deep-seated, slowly propagating smoldering fire. In addition, there is a reluctance by the facility owner to expose the equipment to extraneous particulates of any type. Independent methods for testing the performance of fire detection system decision algorithms are non-existent but would give the users more confidence in the systems. New test methods are likely to be needed to confirm a systems' response to non-fire signatures, once a consensus of the critical non-fire states is reached.